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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :
B01D 47/00, 51/08, 53/00

A1

(11) International Publication Number: WO 94/26391

(43) International Publication Date: 24 November 1994 (24.11.94)

(21) International Application Number: PCT/SE94/00447

(22) International Filing Date: 13 May 1994 (13.05.94)

(30) Priority Data:
9301713-5 19 May 1993 (19.05.93) SE

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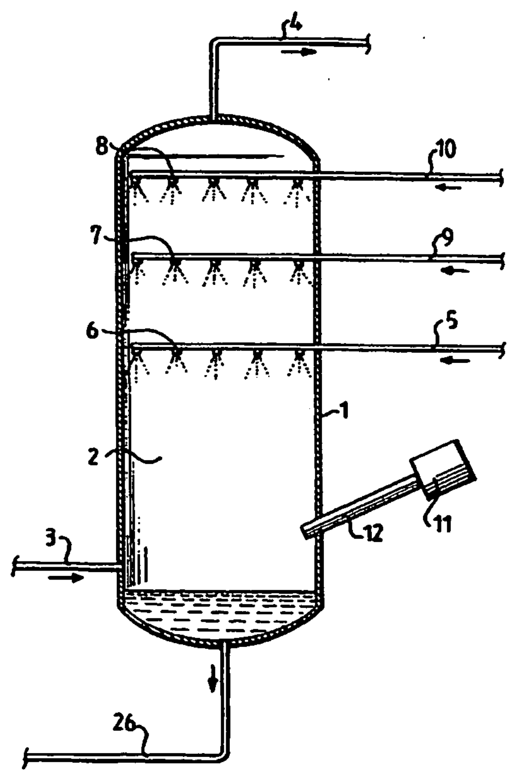
(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KG, KP, KR, KZ, LK, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: TREATING PROCESS GAS

(57) Abstract

A method of continuously treating a gas obtained from an industrial process, to separate particles and/or liquid and/or gaseous substances from the gas and, if applicable, to transfer heat from or to the gas, the gas being introduced into a treatment chamber (2) and brought into contact with at least one treating liquid which is suspended in the gas in the form of drops that absorb said particles and substances and receive or emit heat from and to the gas, respectively. The drops are collected, and liquid and cleaned gas are removed through different outlets (26, 4). The treatment liquid is supplied in an amount sufficient to obtain an equilibrium state between the two phases. According to the invention the treatment is performed while the gas is being exposed to infra-sound.



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Treating process gas

The present invention relates to a method of continuously treating a gas obtained from an industrial process, to separate particles and/or liquid and/or gaseous substances from the gas and, if applicable, to transfer heat from or to the gas, the gas being introduced into a treatment chamber and brought into contact with at least one treating liquid which is suspended in the gas in the form of drops that absorb said particles and substances and receive or emit heat from and to the gas, respectively, said drops then being collected and the liquid thus collected being removed via an outlet which is spaced from an outlet for removing the gas cleaned, the amount of the treating liquid supplied being sufficient to obtain a state of equilibrium between gas and liquid in the treatment chamber.

Transfer resistance always exists when mass or heat is being transferred between two media. This resistance is of great significance to the efficiency of a process step and if it can be reduced efficiency will be improved.

The object of the present invention is to provide a method of continuously treating a process gas, which will result in improved transfer of heat and mass between gas phase and liquid phase, the gas phase of which being the continuous phase, and in improved separation of particles out of the gas.

The method according to the invention is characterized in that the treatment is performed while the gas is being exposed to infra-sound.

According to a suitable embodiment of the invention the gas is exposed to infra-sound having a frequency of at most 150 Hz, preferably at most 40 Hz and most preferred

at most 20 Hz. The sound intensity in the zone for absorption and transfer of heat exceeds 120 dB, preferably at least 140 dB. The infra-sound is generated by at least one infra-sound generator.

According to a suitable embodiment of the invention the process gas contains sulphurous gases, such as SO_2 and H_2S, which are absorbed by liquid drops obtained from an alkaline water solution. The process gas suitably contains particles which have been formed upon sublimation of vaporized substances and which are absorbed by the liquid drops.

According to another suitable embodiment of the invention the treatment is performed in a Venturi scrubber or a spray tower scrubber.

According to another embodiment of the invention the treatment is performed as a selective absorption, absorption of one component in the process gas being in the first place limited by the convective mass transport, whereas absorption of other components, absorption of which is undesired, is limited by other parameters such as reaction velocities in the liquid phase.

According to a special embodiment of the invention the process gas contains H_2S and CO_2, and H_2S is absorbed selectively by the alkali-containing liquid drops, while CO_2 substantially accompanies the cleaned gas out of the treatment chamber.

According to a further embodiment of the invention the process gas has a higher temperature than the treatment liquid and heat is absorbed by the liquid drops moving downwards in counterflow to or concurrent with the process gas in a scrubber, preferably a spray tower scrubber.

According to a further embodiment of the invention the gas originates from a combustion process for sulphite waste liquor containing SO_2.

According to a further embodiment of the invention the gas originates from an MgO boiler containing SO_2 and the absorption liquid contains alkali in the form of hydrated MgO.

According to a further embodiment of the invention the treatment is carried out at a pressure in the treatment chamber of from atmospheric pressure up to 150 bar.

The invention will be described further with reference to the drawings.

Figure 1 shows schematically a gas washing apparatus for treating combustion gas with suspended liquids at various levels.

Figure 2 shows schematically a Venturi scrubber for cleaning flue gas from a magnesium sulphite steam boiler.

With reference to Figure 1, it is shown schematically therein an apparatus for treating a combustion gas recovered when gasifying black liquor in a gasification reactor containing gaseous substances or components including CO, H_2, H_2S, CO_2 and H_2O. The apparatus is in the form of a gas washing apparatus including a closed vertical cylindrical vessel 1 having a washing chamber 2. The combustion gas is transferred to the vessel from the gasification reactor (not shown) via a pipe 3 and is introduced in the lower part of the washing chamber 2. The combustion gas flows up through the washing chamber and washed gas leaves the top of the vessel via a pipe 4 to be used as combustion gas and/or in the production of

chemicals. Alkali liquid, such as green liquor, is also produced in the gasification reactor, part of this being supplied to the vessel 1 via a pipe 5 provided with openings in the form of a plurality of nozzles 6 at a central level in the washing chamber 2, from which the alkali liquid is fed out as liquid drops.

Two more sets of nozzles 7, 8 are arranged at different levels above the first-mentioned liquor nozzles 6. A pipe 9 is connected to the lower of these two additional sets of nozzles 7, 8 for the supply of water containing NaOH or Na_2CO_3, and a pipe 10 is connected to the upper nozzles 8 for the supply of water containing no additives, the water being fed out of these nozzles as drops. The liquid drops fall down by their own weight through the washing chamber 2, encountering the gas flowing upwards, and then collecting at the bottom of the vessel 1. The liquid collected is fed back to the gasification reactor via a pipe 26 to be mixed with the green liquor therein.

According to the present invention the gas washing apparatus is equipped with a sound generator 11, the resonance tube 12 of which is connected to the vessel 1 and has its orifice in the washing chamber 2. The resonance tube 12 is suitably inclined somewhat downwardly as illustrated in Figure 1, thus preventing liquid from entering the sound generator. If desired one or several more sound generators can be connected to the gas washer.

In an alternative embodiment (not shown) a bell-bottom is arranged in the upper part of the vessel, just above the nozzles 7, and weak liquor or similar alkaline liquid is supplied via pipe 10 and nozzles 8 and then removed from the bell-bottom which forms a liquid lock and through which the gas is pressed upwardly to be subjected to a

washing step. In this case a sound generator is also arranged in the space above the bell-bottom.

Figure 2 shows schematically an apparatus for treating a flue gas obtained on combustion of concentrated spent liquor in a magnesium sulphite steam boiler, said gas having a high sulphur dioxide content. The apparatus is in the form of a Venturi scrubber in which the flue gas is cleaned with liquid in order to recover the sulphur. The Venturi scrubber comprises a closed vertical Venturi vessel 13 enclosing a cleaning chamber 14. The flue gas is transferred from the MgO steam boiler (not shown) to the Venturi vessel via a pipe 15 and is introduced at the upper end of the Venturi vessel 13, thereafter flowing down through the cleaning chamber 14. The lower end of the Venturi vessel 13 opens via a connection 16 into a vertical separation vessel 17 through which the cleaned gas flows upwards to be discharged via a conduit 18. Liquid is supplied via a pipe 19 connected to one or more downwardly directed nozzles 20 located in the Venturi neck 21. The liquid is supplied through the nozzles 20 in the form of drops which thus move concurrent with the flue gas. The liquid drops accompany the flue gas and are collected at the bottom of the adjacent separation vessel 17, and a part of the liquid collected is fed out via a circulation pipe 22 which is connected to the inlet pipe 19 for mixing with clean liquid, while the other part is fed out via a level pipe 23 as scrubbing liquid for the recovery of sulphate catched therein. The liquid supplied suitably contains alkali additives, such as sodium hydroxide or sodium carbonate, in order to absorb sulphur dioxide and thus influence the sulphur dioxide content in the flue gas.

According to the present invention the Venturi scrubber is equipped with a sound generator 24, the resonance tube 25 of which is connected to the Venturi vessel 13 and

opens into the cleaning chamber 14 a little way below the Venturi neck 21. The resonance tube 25 is suitably inclined downwardly as illustrated in Figure 2. If desired one or more additional sound generators can be connected to the Venturi scrubber. They should be located after the Venturi neck because the active mass and heat transfer zone extends from the Venturi neck and downwardly. A significant pressure drop also occurs in the Venturi neck, which also entails sound losses.

The sound generators 11, 24 are of the type that generate low-frequency sound, i.e. infra-sound, with a frequency of at most 150 Hz, preferably at most 40 Hz and most preferred at most 20 Hz. The sound intensity must be sufficiently high to ensure improved mass and heat transfer. The sound level should exceed 120 dB, preferably at least 140 dB, in the zone where mass and heat transfer occurs.

It will be understood that the gas must constitute the continuous phase if the infra-sound is to be able to reproduce itself right up to the contact surface between gas and liquid. Similarly the contact means, i.e. the treatment vessel, must have a relatively large free volume. The conditions in the nozzle and Venturi scrubbers described above are very favourable to enable the infra-sound to reproduce itself to all the places where liquid and gas come into contact with each other. Contact means in the form of filler columns may therefore be unsuitable since the sound will be absorbed by the packing material therein.

If the flue gases contain CO_2 and H_2S, CO_2 shall as far as possible pass straight through the scrubber without reacting with the treating liquid or the scrubber liquid. CO_2 absorption is mainly kinetic-controlled whereas H_2S absorption is diffusion-controlled. The present invention

with infra-sound exposure disintegrating the diffusion layers enables both control and intensification of the desired absorption process. This in turn means that the selectivity with regard to H_2S in relation to CO_2 is improved.

In the gas washing apparatus or nozzle scrubber according to Figure 1, for instance, the liquid is sprayed into the upper half of the scrubber and the liquid drops formed fall downwardly while the gas rises, thereby producing counterflow contact. The liquid drops will have a velocity in relation to the gas. The relative velocity between gas and liquid drops contributes to the mass and heat transfer. Immediately after the spray nozzle the liquid drops may have considerably higher velocity than lower down where the liquid drops are retarded by the flow resistance in the gas.

When the gas in the described treatment chambers is exposed to the low-frequency sound waves it acquires an oscillatory movement in various directions, as well as its movement as it flows from inlet to outlet. The relative velocity of the liquid drops will therefore vary. This variation results in the liquid drops having sometimes a higher relative velocity than normal to the gas and sometimes a lower relative velocity in the falling direction of the drops of liquid. At the higher velocity the thickness of the boundary layers decreases, thereby improving the mass and heat transfer. The varying gas velocity around the drops results in, on an average thinner boundary layer than without oscillation. A different type of boundary layer is also obtained than with a constant velocity, since the boundary layer is renewed and constantly changes. When the liquid drops have acquired the higher velocity they will also be retarded, whereas when the velocity is lower the drops will accelerate somewhat expressed as relative velocity.

However, the retardation effect will be strongest thus causing the liquid drops to have a longer duration of stay than the gas. The infra-sound also causes the gas to move in other directions than its main direction of flow. This means that the liquid drops moving in counterflow to the gas (Figure 1), will also be subjected to lateral movements in relation to the gas. This in turn means that the liquid drops are forced to move laterally in a direction perpendicular to the flow direction of the gas. The liquid drops therefore acquire a longer relative path of movement and duration of stay down through the gas washing apparatus, and is more effectively exposed to the gas since the boundary layer impeding transport is disintegrated by the infra-sound.

Equivalent effects are obtained with a contact apparatus in accordance with the concurrent principle (Figure 2).

If desired, the method according to the invention can be repeated in one or more treatment chambers of the type described located consecutively.

CLAIMS

1. A method of continuously treating a gas obtained from an industrial process, to separate particles and/or liquid and/or gaseous substances from the gas and, if applicable, to transfer heat from or to the gas, the gas being introduced into a treatment chamber (2) and brought into contact with at least one treating liquid which is suspended in the gas in the form of drops that absorb said particles and substances and receive or emit heat from and to the gas, respectively, said drops then being collected and the liquid thus collected being removed via an outlet (26; 22, 23) which is spaced from an outlet (4; 18) for removing the gas cleaned, the amount of the treating liquid supplied being sufficient to obtain a state of equilibrium between gas and liquid in the treatment chamber (2), characterized in that the treatment is performed while the gas is being exposed to infra-sound.

2. A method as claimed in claim 1, characterized in that the gas is exposed to infra-sound having a frequency of at most 150 Hz, preferably at most 40 Hz and most preferred at most 20 Hz.

3. A method as claimed in claim 1 or 2, characterized in that the sound intensity in the zone for absorption and transfer of heat exceeds 120 dB, preferably at least 140 dB.

4. A method as claimed in any of claims 1-3, characterized in that the infra-sound is generated by at least one infra-sound generator (11).

5. A method as claimed in any of claims 1-4, characterized in that the process gas contains sulphurous

gases, such as SO_2 and H_2S, which are absorbed by liquid drops obtained from an alkaline water solution.

6. A method as claimed in any of claims 1-4, characterized in that the process gas contains particles which have been formed upon sublimation of vaporized substances and which are absorbed by the liquid drops.

7. A method as claimed in any of claims 1-6, characterized in that the treatment is performed in a Venturi scrubber (13) or a spray tower scrubber.

8. A method as claimed in any of claims 1-7, characterized in that the treatment is performed as a selective absorption, absorption of one component in the process gas being in the first place limited by the convective mass transport, whereas absorption of other components, absorption of which is undesired, is limited by other parameters such as reaction velocities in the liquid phase.

9. A method as claimed in any of claims 1-5, 7 and 8, characterized in that the process gas contains H_2S and CO_2 and that H_2S is absorbed selectively by the alkali-containing liquid drops, while CO_2 substantially accompanies the cleaned gas out of the treatment chamber (2).

10. A method as claimed in any of claims 1-9, characterized in that the process gas has a higher temperature than the treatment liquid and that heat is absorbed by the liquid drops moving downwards in counterflow to or concurrent with the process gas in a scrubber, preferably a spray tower scrubber.

11. A method as claimed in any of claims 1-10, characterized in that the gas originates from a

combustion process for sulphite waste liquor containing SO_2.

12. A method as claimed in any of claims 1-10, characterized in that the gas originates from an MgO boiler containing SO_2 and that the absorption liquid contains alkali in the form of hydrated MgO.

13. A method as claimed in any of claims 1-12, characterized in that the treatment is carried out at a pressure of from atmospheric pressure up to 150 bar.

Fig.1

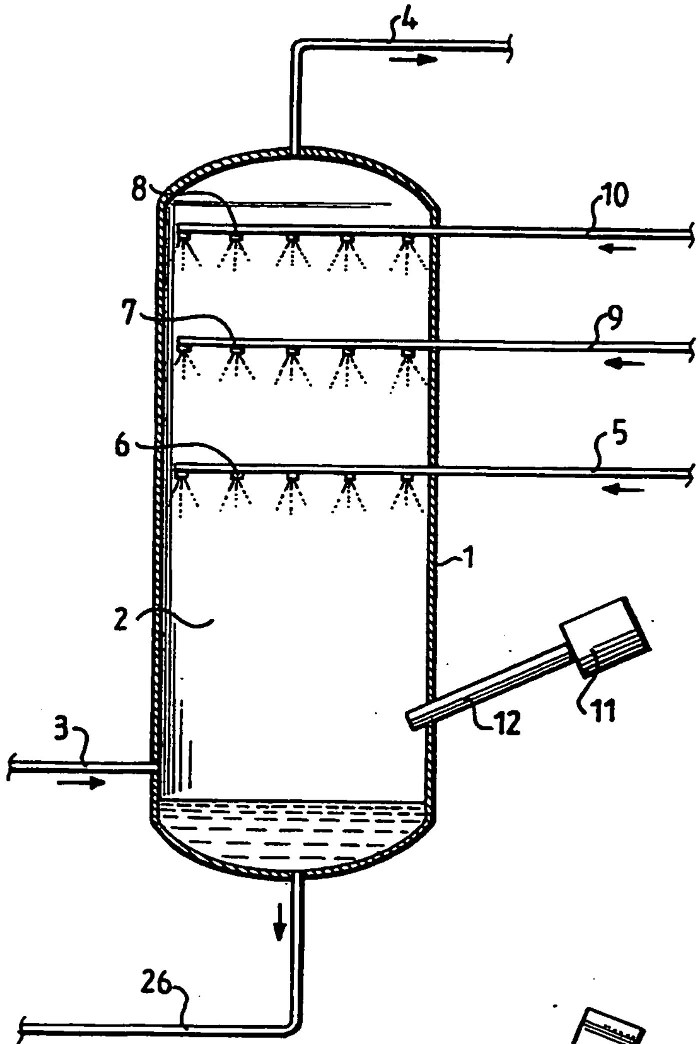
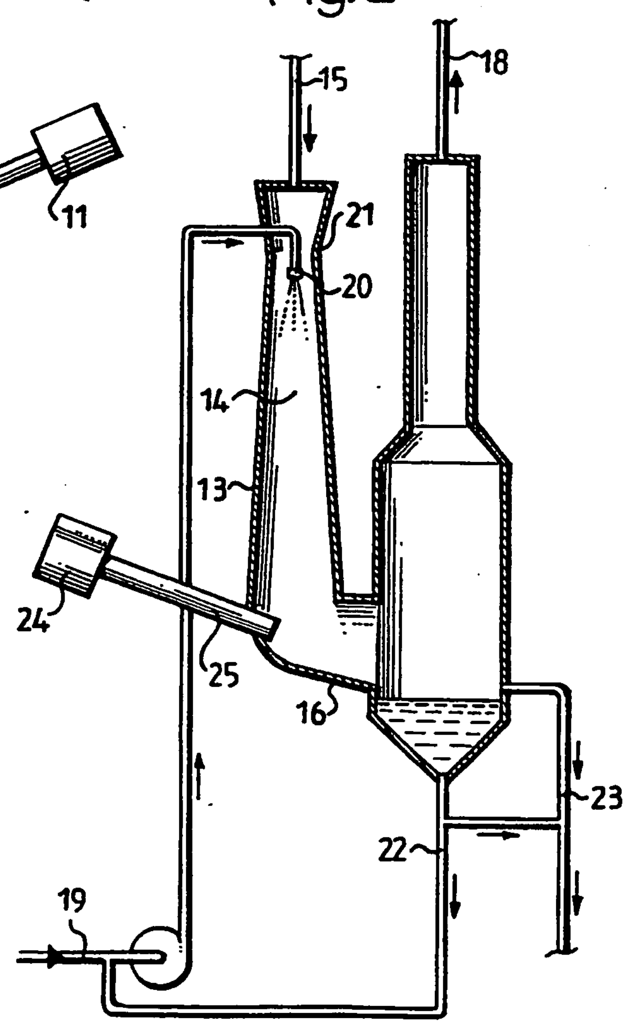


Fig.2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/00447

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B01D 47/00, B01D 51/08, B01D 53/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE, A1, 3507596 (WEHRLE-WERKE AG), 4 Sept 1986 (04.09.86), page 1, line 1 - line 25; page 9, line 21 - page 10, line 8; page 12, line 4 - line 8	1-13
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Y	Derwent's abstract, No 90-266329/35, week 9035, ABSTRACT OF SU, 1519761 (HALURGY RESEARCH IN), 7 November 1989 (07.11.89)	1-13
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Y	Derwent's abstract, No 87-312167/44, week 8744, ABSTRACT OF SU, 1291189 (LVOV POLY), 23 February 1987 (23.02.87)	1-13
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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26 August 1994	31-08-1994
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SE, B, 454409 (ASEA STAL AB), 2 May 1988 (02.05.88), page 3, line 25 - page 4, line 6 --	1
A	GB, A, 1330870 (BRAXTON CORPORATION), 19 Sept 1973 (19.09.73), page 2, line 60 - page 3, line 29, figure 1 -- --------	1

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/07/94

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A1- 3507596	04/09/86	NONE	
SE-B- 454409	02/05/88	SE-A- 8504689	11/04/87
GB-A- 1330870	19/09/73	CA-A- 947671	21/05/74
		DE-A- 2060617	16/06/71
		US-A- 3681009	01/08/72